

4. Methodology for Assessing Failure Probabilities

A primary purpose of this study is to develop estimates of the relative probabilities of occurrence of a Mode-5 failure response for Atlas, Delta, Titan, and as a by-product, for other launch vehicles as well. Natural fallouts of this effort are the relative probabilities of occurrence of other failure-response modes used in program DAMP as well as overall vehicle failure probabilities. There are at least two approaches commonly used in estimating launch-vehicle failure probabilities: (1) a so-called parts-analysis or engineering approach, involving an engineering assessment of the reliability of various parts and components comprising each missile subsystem, and the effects of a part, component or subsystem failure; and (2) an empirical statistical approach based on actual launch results. There are serious problems with both approaches.

4.1 The Parts-Analysis Approach

A description of this approach, its difficulties and shortcomings, are discussed in some detail in a draft report by Booz•Allen & Hamilton, Inc.^[4] prepared in 1992 for the Air Force Space Command. Since we cannot improve on the ideas and words expressed by Booz•Allen, we quote the following from that report:

“The engineering approach for calculation of launch vehicle success rates is based on measurement/estimation of piece-part reliabilities and their combination into reliability block models of the launch system. These block models ... include consideration of the criticality of individual components, the presence (or absence) of redundant capabilities, the likelihood that one component failure might cause a failure in another component, as well as other needed data. By combining the individual piece-part reliabilities in this model, the engineering approach produces an overall reliability estimate for the launch system.

“The engineering approach has several significant limitations that tend to reduce confidence in its results. First, the approach assumes that the interrelationships among and between sub-systems are understood sufficiently to enable development of a reliability block diagram. This assumption is highly questionable in complex systems, such as space launch vehicles, whose operational histories include many anecdotes regarding unexpected relationships between ‘independent’ sub-systems.

“The second drawback of the engineering approach is that it assesses the reliability of the system **in a perfectly assembled condition**. As a result, it assesses reliability without regard to manufacturing, processing, or operations variations and errors.”

Effects typically overlooked or ignored include:

- a. Improper installation of components
- b. Erroneous computer programs